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(54) **GROUP DRIVING STYLE LEARNING FRAMEWORK FOR AUTONOMOUS VEHICLES**

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(Continued)

(52) **U.S. Cl.**
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(Continued)

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(Continued)

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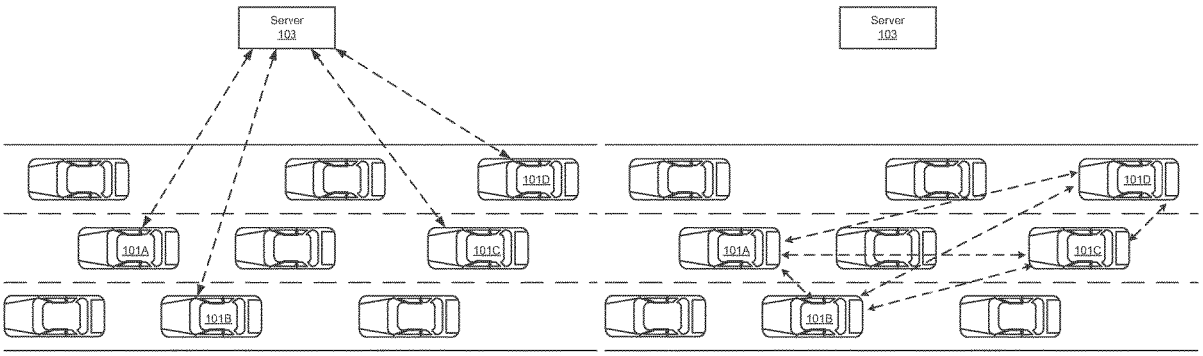
(57) **ABSTRACT**

A social driving style learning framework or system for autonomous vehicles is utilized, which can dynamically learn the social driving styles from surrounding vehicles and adopt the driving style as needed. Each of the autonomous vehicles within a particular driving area is equipped with the driving style learning system to perceive the driving behaviors of the surrounding vehicles to derive a set of driving style elements. Each autonomous vehicle transmits the driving style elements to a centralized remote server. The server aggregates the driving style elements collected from the autonomous vehicles to determine a driving style corresponding to that particular driving area. The server transmits the driving style back to each of the autonomous vehicles. The autonomous vehicles can then decide whether to adopt the driving style, for example, to follow the traffic flow with the rest of the vehicles nearby.

22 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

G06N 20/00	(2019.01)
B60W 30/095	(2012.01)
G08G 1/01	(2006.01)
G05D 1/02	(2020.01)
G05D 1/00	(2006.01)
B60W 50/00	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC G08G 1/096791; G05D 1/0291; G05D 1/021; G05D 1/0011; G05D 1/0088; G05D 2201/0213; G06N 20/00; B60W 30/0956; B60W 2050/0077; B60W 2050/008; B60W 40/09

See application file for complete search history.

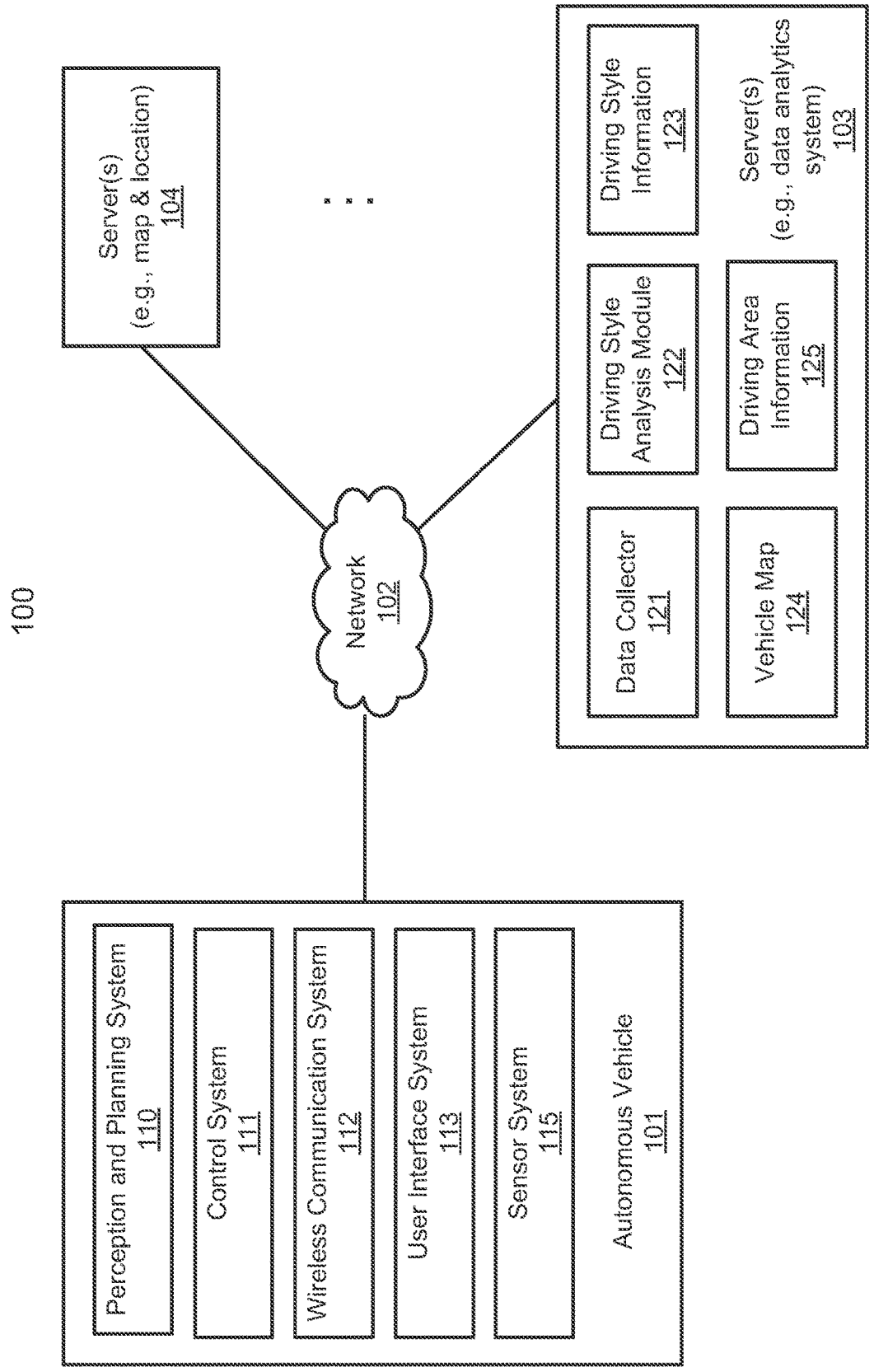
100
Autonomous Vehicle
101
Perception and Planning System
110
Control System
111
Wireless Communication System
112
User Interface System
113
Sensor System
115
Network
102
Server(s)
(e.g., map & location)
104
Server(s)
(e.g., data analytics system)
103
Data Collector
121
Driving Style Analysis Module
122
Vehicle Map
124
Driving Area Information
125
Driving Style Information
123

FIG. 1

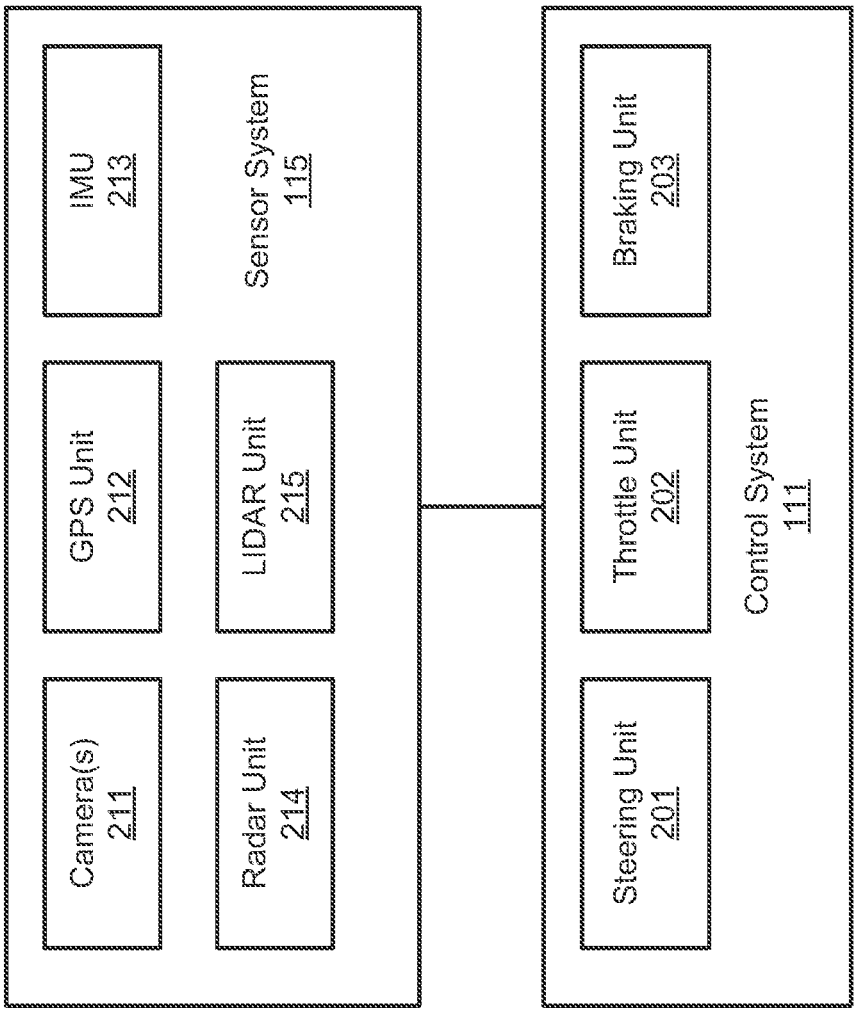
Sensor System
115
Camera(s)
211
GPS Unit
212
IMU
213
Radar Unit
214
LIDAR Unit
215
Control System
111
Steering Unit
201
Throttle Unit
202
Braking Unit
203

FIG. 2

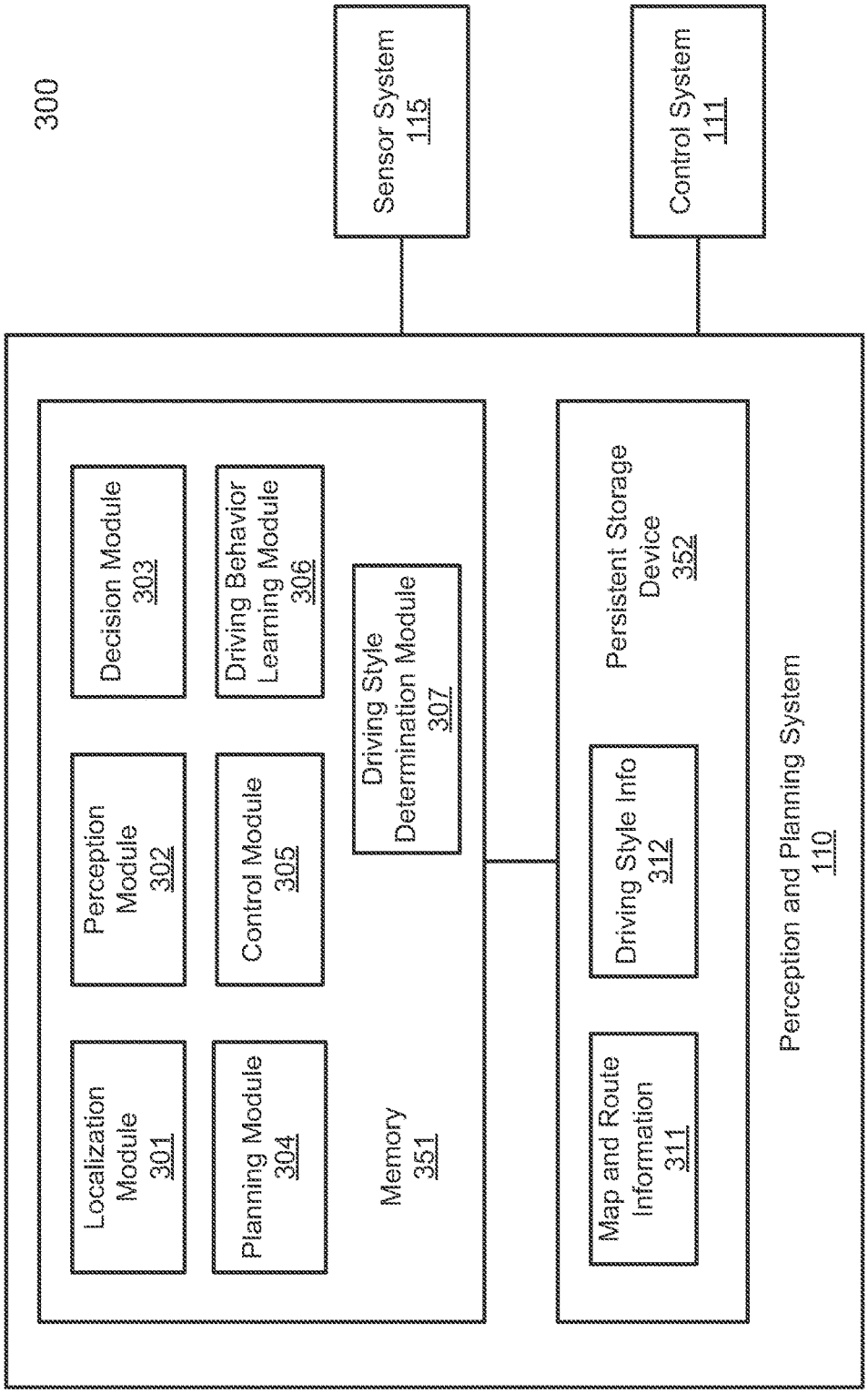
300
Sensor System 115
Control System 111
Perception and Planning System 110
Memory 351
Localization Module 301
Perception Module 302
Decision Module 303
Planning Module 304
Control Module 305
Driving Behavior Learning Module 306
Driving Style Determination Module 307
Persistent Storage Device 352
Map and Route Information 311
Driving Style Info 312

FIG. 3

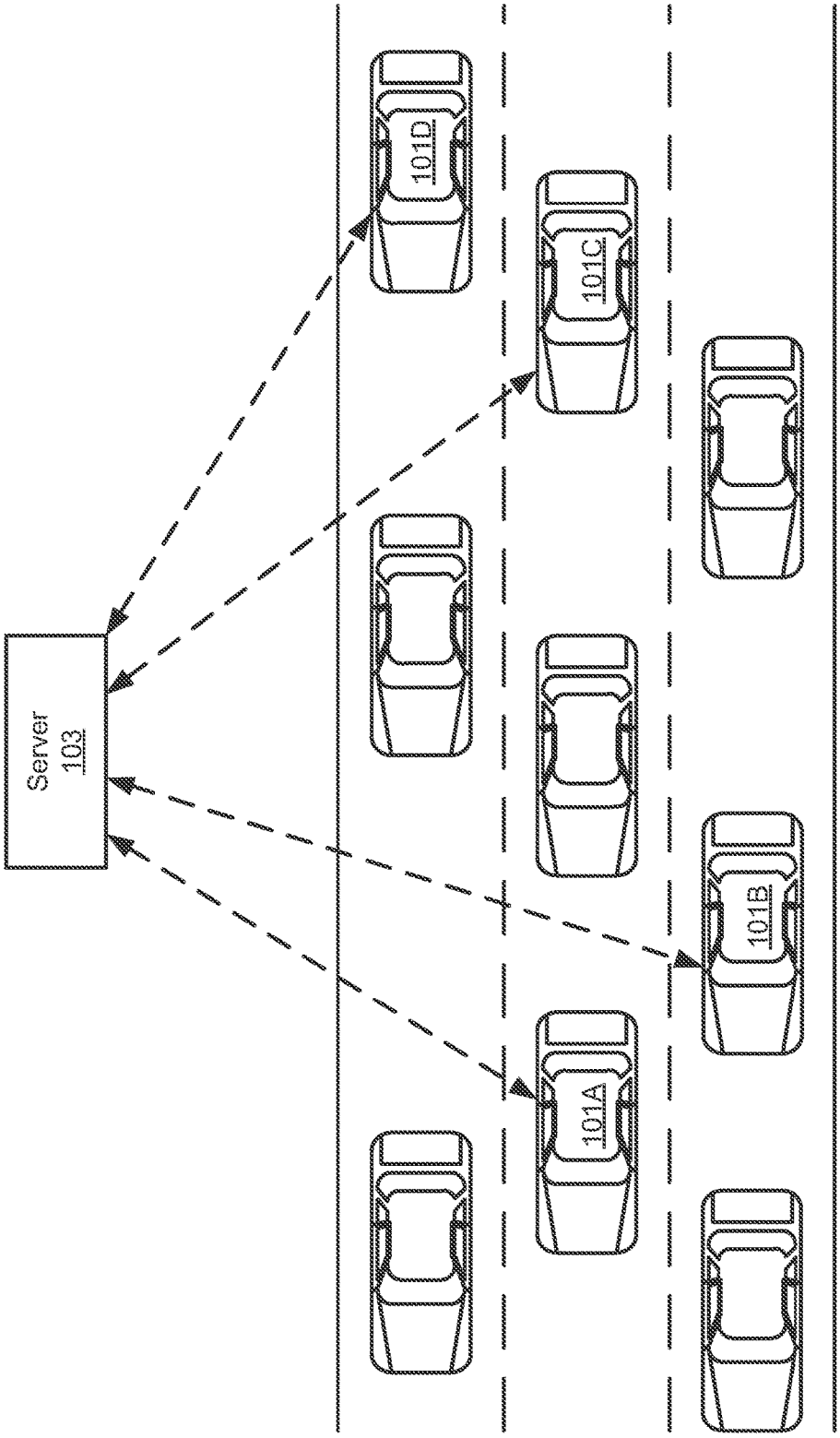

FIG. 4

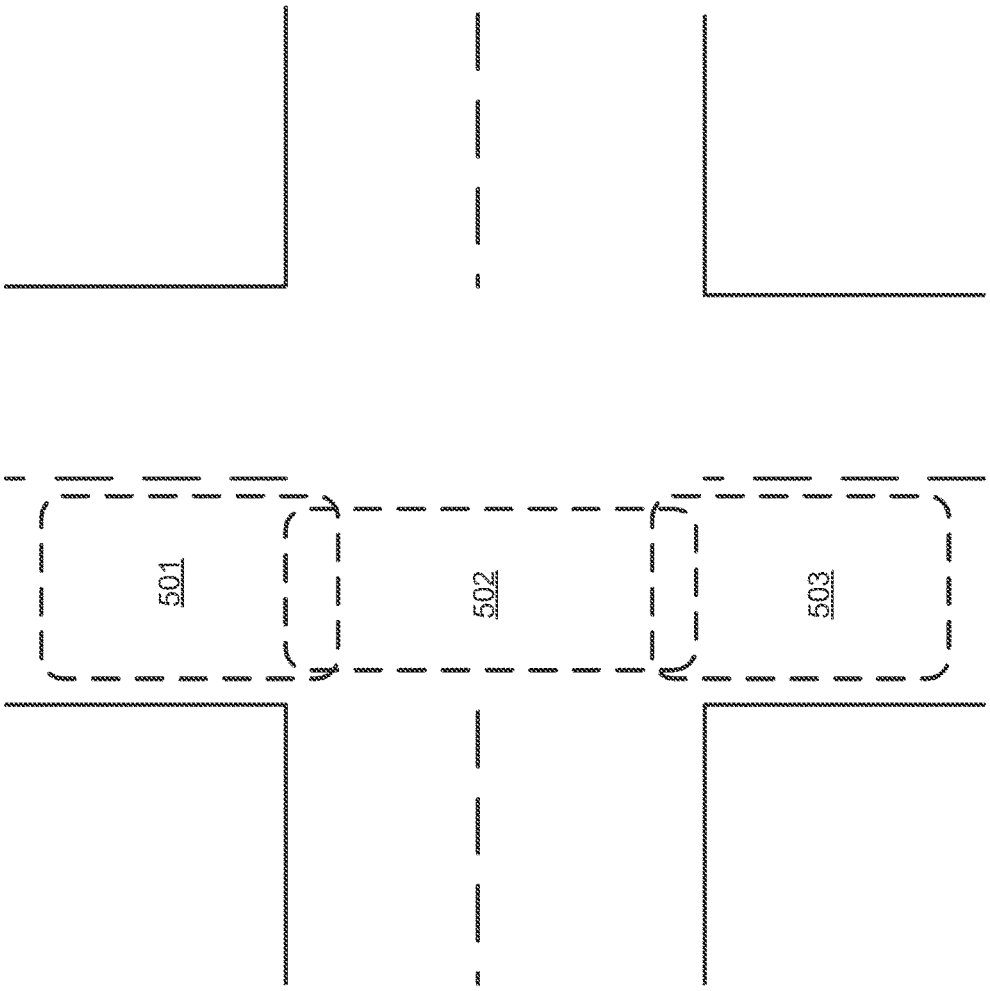

FIG. 5

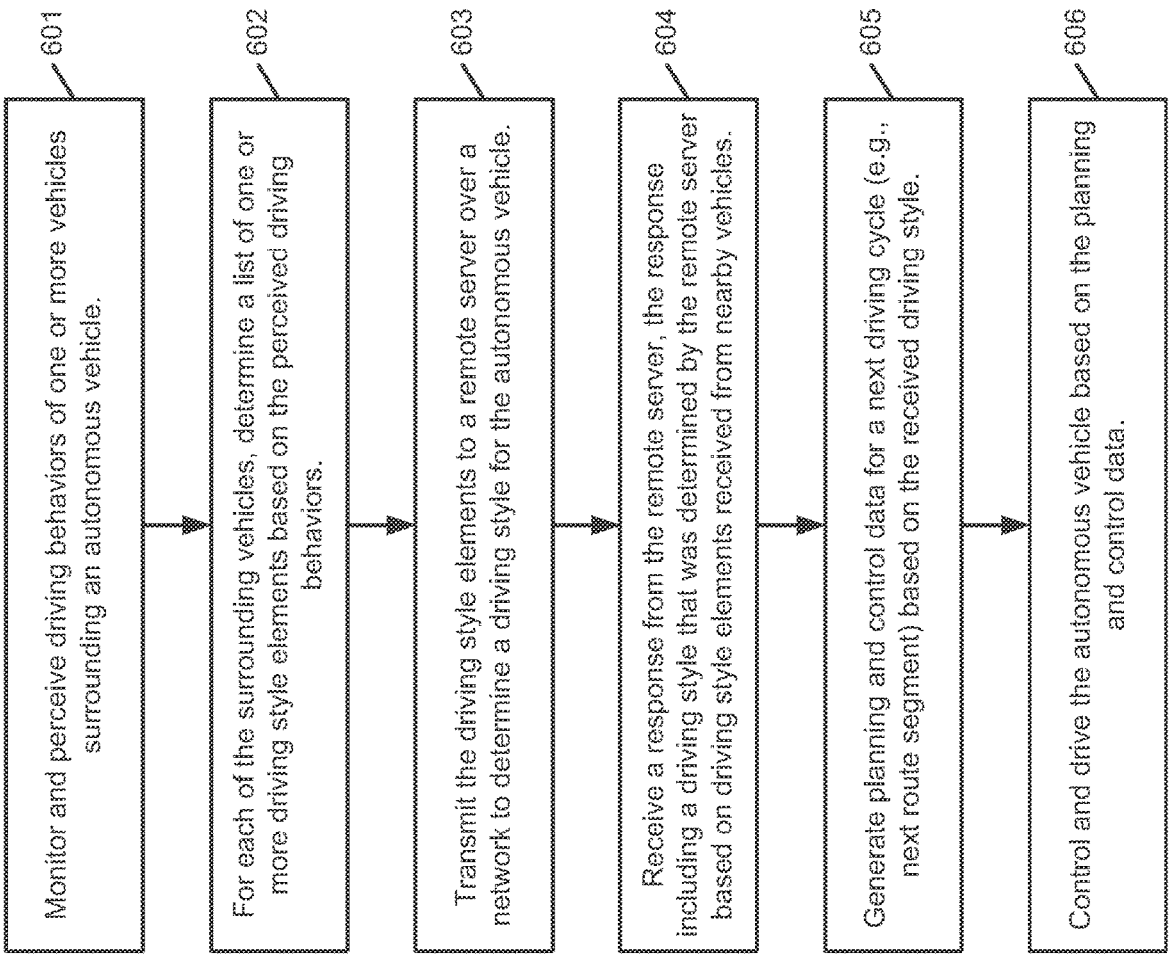
600
601
Monitor and perceive driving behaviors of one or more vehicles surrounding an autonomous vehicle.
602
For each of the surrounding vehicles, determine a list of one or more driving style elements based on the perceived driving behaviors.
603
Transmit the driving style elements to a remote server over a network to determine a driving style for the autonomous vehicle.
604
Receive a response from the remote server, the response including a driving style that was determined by the remote server based on driving style elements received from nearby vehicles.
605
Generate planning and control data for a next driving cycle (e.g., next route segment) based on the received driving style.
606
Control and drive the autonomous vehicle based on the planning and control data.

FIG. 6

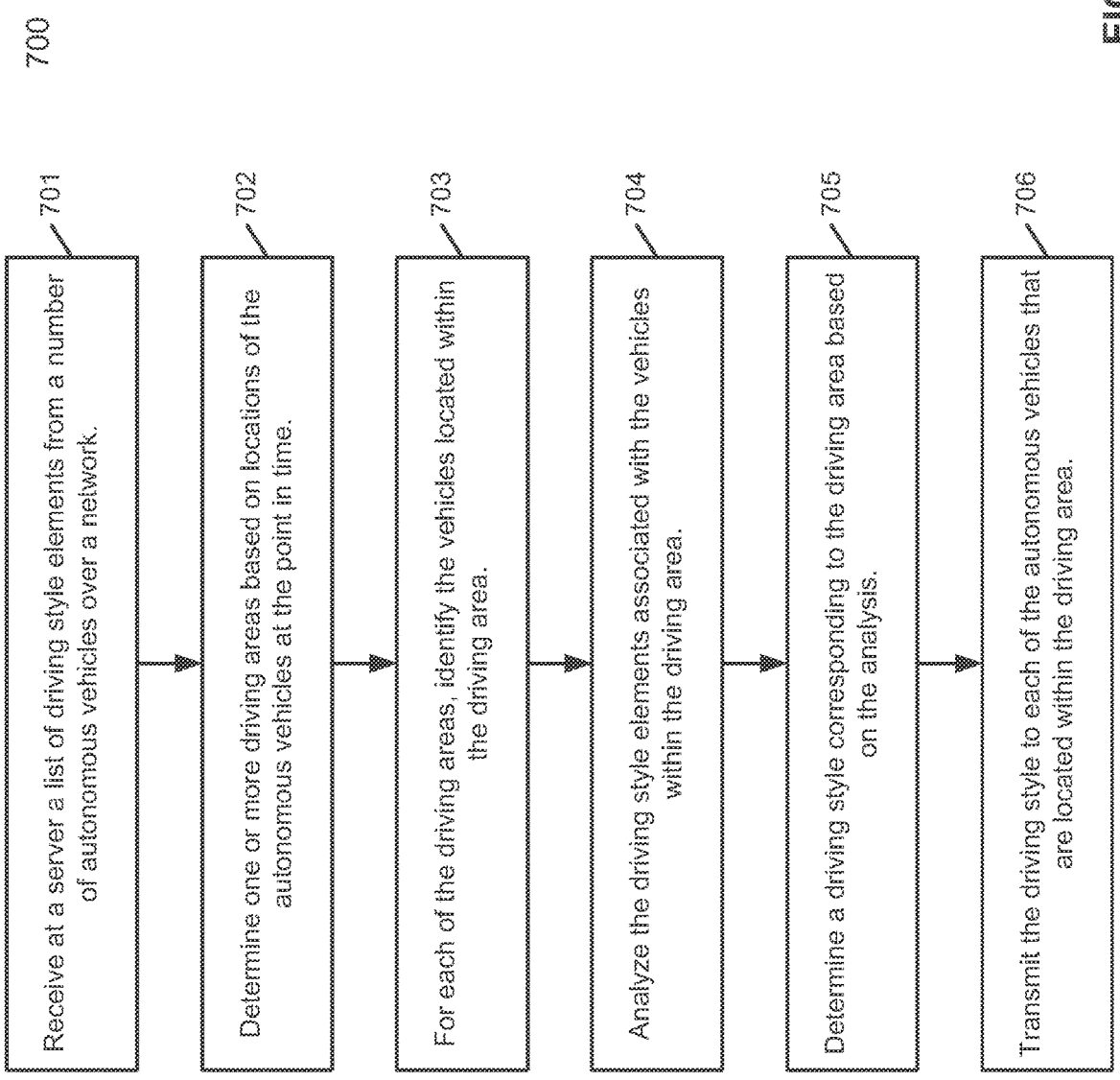
700
701
Receive at a server a list of driving style elements from a number of autonomous vehicles over a network.
702
Determine one or more driving areas based on locations of the autonomous vehicles at the point in time.
703
For each of the driving areas, identify the vehicles located within the driving area.
704
Analyze the driving style elements associated with the vehicles within the driving area.
705
Determine a driving style corresponding to the driving area based on the analysis.
706
Transmit the driving style to each of the autonomous vehicles that are located within the driving area.

FIG. 7

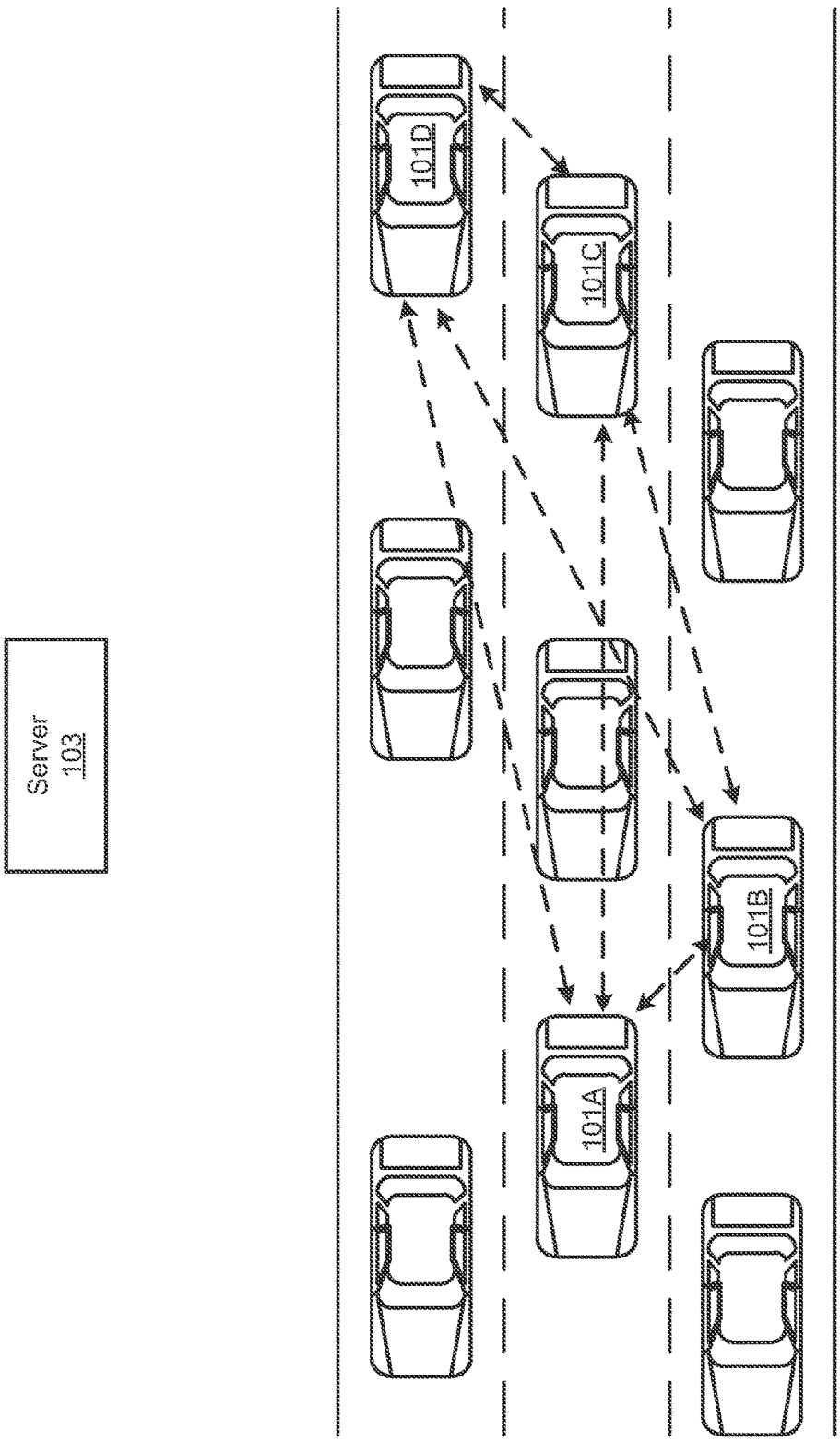

FIG. 8

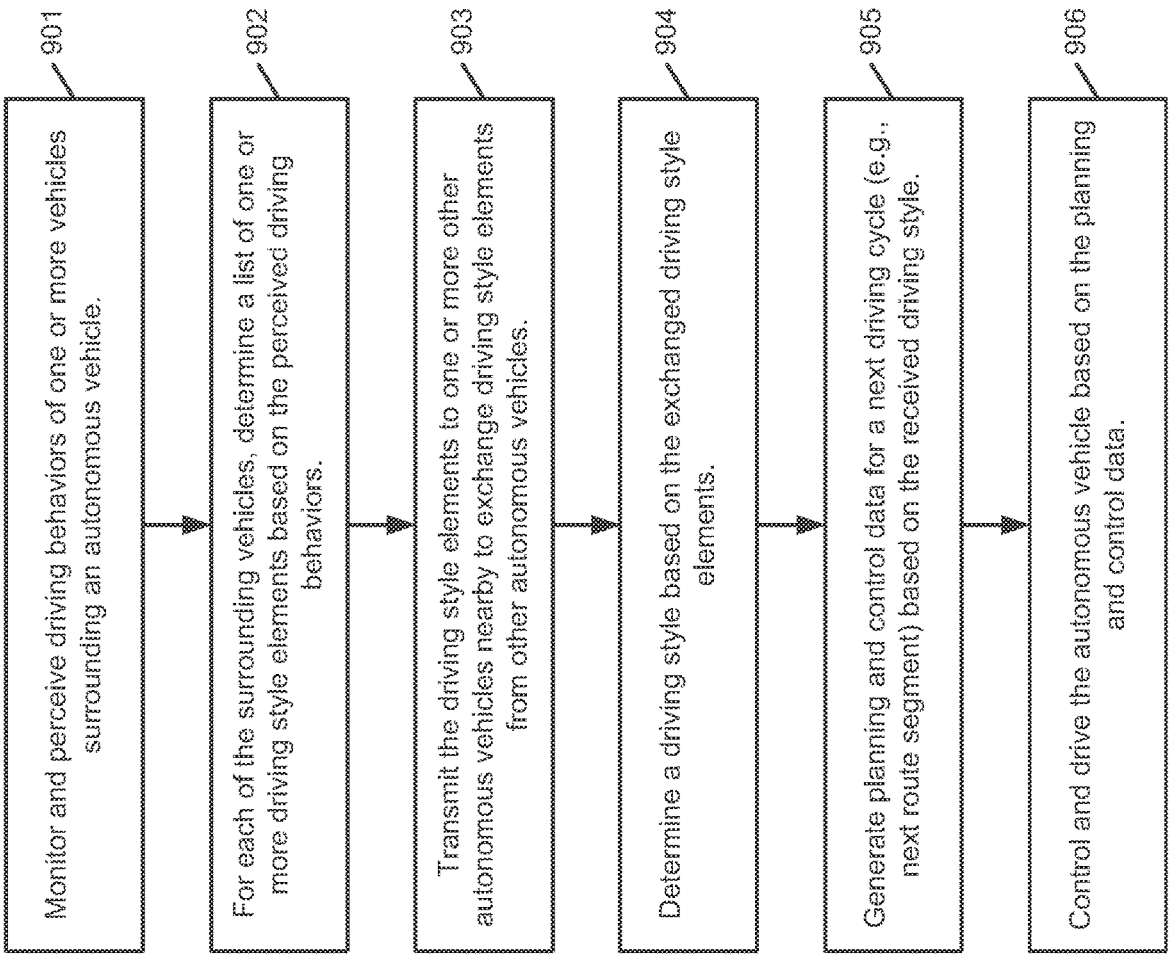
900
901
Monitor and perceive driving behaviors of one or more vehicles surrounding an autonomous vehicle.
902
For each of the surrounding vehicles, determine a list of one or more driving style elements based on the perceived driving behaviors.
903
Transmit the driving style elements to one or more other autonomous vehicles nearby to exchange driving style elements from other autonomous vehicles.
904
Determine a driving style based on the exchanged driving style elements.
905
Generate planning and control data for a next driving cycle (e.g., next route segment) based on the received driving style.
906
Control and drive the autonomous vehicle based on the planning and control data.

FIG. 9

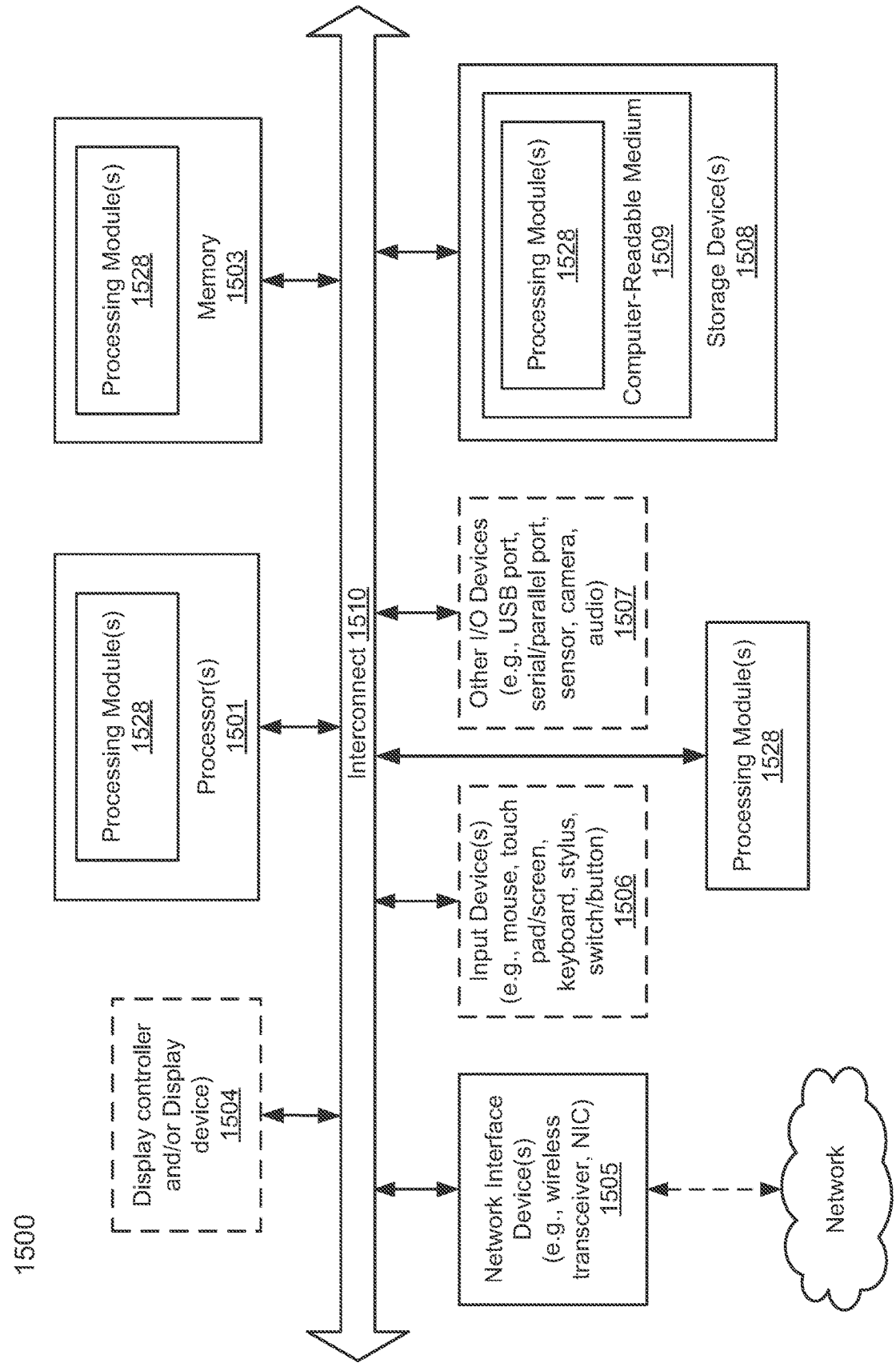
1500
Processing Module(s) 1528
Memory 1503
Processing Module(s) 1528
Processor(s) 1501
Processing Module(s) 1528
Computer-Readable Medium 1509
Storage Device(s) 1508
Interconnect 1510
Other I/O Devices (e.g., USB port, serial/parallel port, sensor, camera, audio) 1507
Input Device(s) (e.g., mouse, touch pad/screen, stylus, keyboard, switch/button) 1506
Processing Module(s) 1528
Display controller and/or Display device) 1504
Network Interface Device(s) (e.g., wireless transceiver, NIC) 1505
Network

FIG. 10

GROUP DRIVING STYLE LEARNING FRAMEWORK FOR AUTONOMOUS VEHICLES

RELATED APPLICATIONS

This application is a continuation application of a co-pending U.S. patent application Ser. No. 15/292,970, filed Oct. 13, 2016, which is incorporated by reference herein in its entirety.

TECHNICAL FIELD

Embodiments of the present invention relate generally to operating autonomous vehicles. More particularly, embodiments of the invention relate to determining driving styles of autonomous vehicles.

BACKGROUND

Vehicles operating in an autonomous mode (e.g., driverless) can relieve occupants, especially the driver, from some driving-related responsibilities. When operating in an autonomous mode, the vehicle can navigate to various locations using onboard sensors, allowing the vehicle to travel with minimal human interaction or in some cases without any passengers.

Group driving styles, relatively stable part of group driving behaviors at the strategic, tactical, and operational levels, varies in different areas due to local social norms and cultural values, surrounding environments and traffic conditions, and local weather. For example, in suburban areas, people's driving styles are more on a defensive driving side and in urban areas people are more on an aggressive driving side. In addition, people drive more cautiously in a raining day than usual.

An autonomous vehicle (also referred to as an autonomous driving vehicle or ADV) needs to adopt local driving styles (or similar ones) to keep the traffic flow harmonious, and to make a trip safe and time efficient. For example, an autonomous vehicle may take a much longer time to complete a trip if a very defensive driving strategy is adopted in an urban area because most of vehicles are more on an aggressive driving side, as they may cut in frequently. Alternatively, an autonomous vehicle may have a higher risk of an accident if an aggressive driving style is used in a raining day as all surrounding vehicles are driving cautiously and slowly. A social driving style has many aspects and may change dynamically thus it is hard to preconfigure a set of rules for that in an autonomous vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are illustrated by way of example and not limitation in the figures of the accompanying drawings in which like references indicate similar elements.

FIG. **1** is a block diagram illustrating a networked system according to one embodiment of the invention.

FIG. **2** is a block diagram illustrating an example of an autonomous vehicle according to one embodiment of the invention.

FIG. **3** is a block diagram illustrating an example of a perception and planning system used with an autonomous vehicle according to one embodiment of the invention.

FIG. **4** is a block diagram illustrating an autonomous driving configuration according to one embodiment of the invention.

FIG. **5** is a block diagram illustrating an autonomous driving configuration according to another embodiment of the invention.

FIG. **6** is a flow diagram illustrating a process of operating an autonomous vehicle according one embodiment of the invention.

FIG. **7** is a flow diagram illustrating a process of determining driving styles for operating autonomous vehicles according one embodiment of the invention.

FIG. **8** is a block diagram illustrating an autonomous driving configuration according to another embodiment of the invention.

FIG. **9** is a flow diagram illustrating a process of operating an autonomous vehicle according one embodiment of the invention.

FIG. **10** is a block diagram illustrating a data processing system according to one embodiment.

DETAILED DESCRIPTION

Various embodiments and aspects of the inventions will be described with reference to details discussed below, and the accompanying drawings will illustrate the various embodiments. The following description and drawings are illustrative of the invention and are not to be construed as limiting the invention. Numerous specific details are described to provide a thorough understanding of various embodiments of the present invention. However, in certain instances, well-known or conventional details are not described in order to provide a concise discussion of embodiments of the present inventions.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in conjunction with the embodiment can be included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification do not necessarily all refer to the same embodiment.

According to one aspect of the invention, a social driving style learning framework or system for autonomous vehicles is utilized, which can dynamically learn the social driving styles from surrounding vehicles and adopt the driving style as needed. Each of the autonomous vehicles within a particular driving area is equipped with a driving style learning or adoption system to perceive and observe the driving behaviors of the surrounding vehicles to derive a set of driving style elements. Each autonomous vehicle transmits or reports the driving style elements to a centralized remote server (e.g., a cloud server) over a network. The server aggregates the driving style elements collected from the autonomous vehicles to determine a driving style corresponding to that particular driving area. The server then transmits the driving style back to each of the autonomous vehicles that are located within the corresponding driving area. The autonomous vehicles can then decide whether to adopt the driving style, for example, to follow the traffic flow with the rest of the vehicles nearby.

In one embodiment, an autonomous vehicle perceives driving behaviors of the vehicles surrounding the autonomous vehicle. Driving style elements for each of the surrounding vehicles are determined based on its driving behavior. The autonomous vehicle transmits the driving style elements to a centralized remote server over a network. The remote server is communicatively coupled to many

autonomous vehicles and receives driving style elements from each of the autonomous vehicles about the driving behaviors of its surrounding vehicles. The autonomous vehicle receives a driving style from the remote server, which determines a driving style based on the received driving style elements collected from one or more other autonomous vehicles nearby. Based on the received driving style, the autonomous vehicle plans and generates planning and control data to control and drive the autonomous vehicle. As a result, the autonomous vehicle can adopt a driving style similar to other vehicles nearby and to follow the traffic flow smoothly.

According to another aspect of the invention, instead of sending the driving style elements to a centralized server, the autonomous vehicles that are located within a predetermined proximity or driving area may exchange the driving style elements over a wireless network (e.g., a wireless local area network or WLAN) to allow each of the autonomous vehicles to determine a driving style itself based on the driving style elements observed by each autonomous vehicle itself and other autonomous vehicles nearby. That is, each autonomous vehicle aggregates the driving style elements observed by all autonomous vehicles in the area to determine a driving style to adopt. This is particularly useful when a network connection to a centralized server is unavailable.

In one embodiment, a first autonomous vehicle observes driving behaviors of one or more vehicles surrounding the first autonomous vehicle. Driving style elements for each of the surrounding vehicles are determined based on a driving behavior of the surrounding vehicle. A first set of driving style elements representing the driving behaviors of the surrounding vehicles is transmitted from the first autonomous vehicle to a second autonomous vehicle over a wireless network. A second set of driving style elements is received from the second autonomous vehicle, where the second set of driving style elements were determined by the second autonomous vehicle based on a perception of driving behaviors of vehicles surrounding the second autonomous vehicle. A driving style is determined based on the first set of driving style elements and the second set of driving style elements. The driving style includes information describing how the first autonomous vehicle should drive in view of the surrounding vehicles at a point in time. The first autonomous vehicle is controlled and driven based on planning and control data generated based on the driving style.

FIG. **1** is a block diagram illustrating an autonomous vehicle network configuration according to one embodiment of the invention. Referring to FIG. **1**, network configuration **100** includes autonomous vehicle **101** that may be communicatively coupled to one or more servers **103-104** over a network **102**. Although there is one autonomous vehicle shown, multiple autonomous vehicles can be coupled to each other and/or coupled to servers **103-104** over network **102**. Network **102** may be any type of networks such as a local area network (LAN), a wide area network (WAN) such as the Internet, a cellular network, a satellite network, or a combination thereof, wired or wireless. Server(s) **103-104** may be any kind of servers or a cluster of servers, such as Web or cloud servers, application servers, backend servers, or a combination thereof. Servers **103-104** may be data analytics servers, content servers, traffic information servers, map and point of interest (MPOI) severs, or location servers, etc.

An autonomous vehicle refers to a vehicle that can be configured to in an autonomous mode in which the vehicle navigates through an environment with little or no input from a driver. Such an autonomous vehicle can include a sensor system having one or more sensors that are configured to detect information about the environment in which the vehicle operates. The vehicle and its associated controller(s) use the detected information to navigate through the environment. Autonomous vehicle **101** can operate in a manual mode, a full autonomous mode, or a partial autonomous mode.

In one embodiment, autonomous vehicle **101** includes, but is not limited to, perception and planning system **110**, vehicle control system **111**, wireless communication system **112**, user interface system **113**, infotainment system **114**, and sensor system **115**. Autonomous vehicle **101** may further include certain common components included in ordinary vehicles, such as, an engine, wheels, steering wheel, transmission, etc., which may be controlled by vehicle control system **111** and/or perception and planning system **110** using a variety of communication signals and/or commands, such as, for example, acceleration signals or commands, deceleration signals or commands, steering signals or commands, braking signals or commands, etc.

Components **110-115** may be communicatively coupled to each other via an interconnect, a bus, a network, or a combination thereof. For example, components **110-115** may be communicatively coupled to each other via a controller area network (CAN) bus. A CAN bus is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles, but is also used in many other contexts.

Referring now to FIG. **2**, in one embodiment, sensor system **115** includes, but it is not limited to, one or more cameras **211**, global positioning system (GPS) unit **212**, inertial measurement unit (IMU) **213**, radar unit **214**, and a light detection and range (LIDAR) unit **215**. GPS system **212** may include a transceiver operable to provide information regarding the position of the autonomous vehicle. IMU unit **213** may sense position and orientation changes of the autonomous vehicle based on inertial acceleration. Radar unit **214** may represent a system that utilizes radio signals to sense objects within the local environment of the autonomous vehicle. In some embodiments, in addition to sensing objects, radar unit **214** may additionally sense the speed and/or heading of the objects. LIDAR unit **215** may sense objects in the environment in which the autonomous vehicle is located using lasers. LIDAR unit **215** could include one or more laser sources, a laser scanner, and one or more detectors, among other system components. Cameras **211** may include one or more devices to capture images of the environment surrounding the autonomous vehicle. Cameras **211** may be still cameras and/or video cameras. A camera may be mechanically movable, for example, by mounting the camera on a rotating and/or tilting a platform.

Sensor system **115** may further include other sensors, such as, a sonar sensor, an infrared sensor, a steering sensor, a throttle sensor, a braking sensor, and an audio sensor (e.g., microphone). An audio sensor may be configured to capture sound from the environment surrounding the autonomous vehicle. A steering sensor may be configured to sense the steering angle of a steering wheel, wheels of the vehicle, or a combination thereof. A throttle sensor and a braking sensor sense the throttle position and braking position of the vehicle, respectively. In some situations, a throttle sensor and a braking sensor may be integrated as an integrated throttle/braking sensor.

In one embodiment, vehicle control system **111** includes, but is not limited to, steering unit **201**, throttle unit **202** (also referred to as an acceleration unit), and braking unit **203**. Steering unit **201** is to adjust the direction or heading of the vehicle. Throttle unit **202** is to control the speed of the motor or engine that in turn control the speed and acceleration of the vehicle. Braking unit **203** is to decelerate the vehicle by providing friction to slow the wheels or tires of the vehicle. Note that the components as shown in FIG. **2** may be implemented in hardware, software, or a combination thereof.

Referring back to FIG. **1**, wireless communication system **112** is to allow communication between autonomous vehicle **101** and external systems, such as devices, sensors, other vehicles, etc. For example, wireless communication system **112** can wirelessly communicate with one or more devices directly or via a communication network, such as servers **103-104** over network **102**. Wireless communication system **112** can use any cellular communication network or a wireless local area network (WLAN), e.g., using WiFi to communicate with another component or system. Wireless communication system **112** could communicate directly with a device (e.g., a mobile device of a passenger, a display device, a speaker within vehicle **101**), for example, using an infrared link, Bluetooth, etc. User interface system **113** may be part of peripheral devices implemented within vehicle **101** including, for example, a keyword, a touch screen display device, a microphone, and a speaker, etc.

Some or all of the functions of autonomous vehicle **101** may be controlled or managed by perception and planning system **110**, especially when operating in an autonomous driving mode. Perception and planning system **110** includes the necessary hardware (e.g., processor(s), memory, storage) and software (e.g., operating system, planning and routing programs) to receive information from sensor system **115**, control system **111**, wireless communication system **112**, and/or user interface system **113**, process the received information, plan a route or path from a starting point to a destination point, and then drive vehicle **101** based on the planning and control information. Alternatively, perception and planning system **110** may be integrated with vehicle control system **111**.

For example, a user as a passenger may specify a starting location and a destination of a trip, for example, via a user interface. Perception and planning system **110** obtains the trip related data. For example, perception and planning system **110** may obtain location and route information from an MPOI server, which may be a part of servers **103-104**. The location server provides location services and the MPOI server provides map services and the POIs of certain locations. Alternatively, such location and MPOI information may be cached locally in a persistent storage device of perception and planning system **110**.

During traveling of autonomous vehicle **101** along the route, perception and planning system **110** may also obtain real-time traffic information from a traffic information system or server (TIS). Note that servers **103-104** may be operated by a third party entity. Alternatively, the functionalities of servers **103-104** may be integrated with perception and planning system **110**. Based on the real-time traffic information, MPOI information, and location information, as well as real-time local environment data detected or sensed by sensor system **115** (e.g., obstacles, objects, nearby vehicles), perception and planning system **110** can plan an optimal route and drive vehicle **101**, for example, via control system **111**, according to the planned route to reach the specified destination safely and efficiently.

According to one embodiment, referring back to FIG. **1**, each of autonomous vehicles, such as, autonomous vehicle **101**, perceives driving behaviors of the surrounding vehicles, determines driving style elements representing the driving behaviors, and transmits the driving style elements to a centralized server over network **102**, in this example, server **103** operating as a data analytics server, as shown in FIG. **4**. Referring now to FIG. **4**, it shows a particular driving area or driving region **400** that has been previously defined. In this driving area, there are many vehicles travelling within driving area **400**, including autonomous vehicles **101**A-**101**D and other human-driving vehicles.

In one embodiment, each of autonomous vehicles **101**A-**101**D are communicatively coupled to centralized server **103** over a network. For example, each of autonomous vehicles **101**A-**101**D may be communicatively coupled to one or more cellular towers, basestations, or WiFi hot spots, which are in turn coupled to centralized server **103**. According to one embodiment, based on the driving elements receive from autonomous vehicles **101**A-**101**D, server **103** determines a driving style representing the driving style of all vehicles travelling within driving area **400** at the point in time. Server **103** then transmits the driving style back to autonomous vehicles **101**A-**101**D, provided autonomous vehicles **101**A-**101**D are still located within driving area **400**. As a result, autonomous vehicles **101**A-**101**D can adopt to the driving style when planning the next driving or moving cycle.

Referring back to FIG. **1**, in one embodiment, server **103** includes data collector **121** and driving style analysis module **122**. Data collector **121** collects all the driving style elements from all the autonomous vehicles that are communicatively coupled to server **103**. The driving style elements may be stored as a part of driving style information **123** in a persistent storage device such as hard disks. A driving style element may refer to a driving speed of a vehicle, a distance between two vehicles, a deceleration rate of a vehicle, or a distance for deceleration (from deceleration to complete stop). A driving style element may further refer to a frequency of changing lanes, a speed of changing lanes, or a turning angle of changing lanes.

In addition to the driving style elements, data collector **121** further receives the locations of each autonomous vehicle sending the driving style elements, as well as locations of their surrounding vehicles. Server **103** may further maintain vehicle map **124** indicating the locations of the vehicles involved.

In one embodiment, analysis module **122** performs an analysis on driving style information **123** to determine a driving style of a particular driving area, which may be defined as a part of driving area information **125**. A driving area may be a city, a block of a city, a block of a suburban, a segment of a highway, or an intersection, etc. For each of the driving areas, analysis module **122** identifies the driving style elements of the vehicles that are located within the driving area, performs an analysis on the driving style elements, and determines a driving style based on the analysis for that driving area. Analysis module **122** then identifies the autonomous vehicles that are located within the corresponding driving area based on vehicle map **124**. Analysis module **122** then transmits the driving style to the autonomous vehicles that are still located within the driving area at the point in time.

In one embodiment, a driving style may include some or all of the driving style elements described above that represent all of the vehicles travelling within the driving area, such as, for example, averaged driving style elements. For

example, a driving style may refer to an averaged driving speed of vehicles, an averaged distance amongst the vehicles, an averaged deceleration rate of vehicles, an averaged distance for deceleration (e.g., from deceleration to complete stop), an averaged frequency of changing lanes, an averaged speed of changing lanes, or an averaged turning angle of changing lanes.

Note that when autonomous vehicle **101** transmits driving style elements to server **103**, it may be in a first driving area. Thus, the driving style elements represent the driving behaviors of the vehicles located within the first driving area at the time. However, when server **103** determines the driving style for the first driving area and is ready to transmit the driving style of the first driving area, autonomous vehicle **101** may be in a second driving area. Thus, autonomous vehicle **101** may not receive the driving style for the first driving area. Rather, autonomous vehicle **101** may receive the driving style for the second driving area. The second driving style for the second driving area may be determined based on the driving style elements submitted by other autonomous vehicles located within the second driving area.

FIG. **3** is a block diagram illustrating an example of a perception and planning system used with an autonomous vehicle according to one embodiment of the invention. System **300** may be implemented as a part of autonomous vehicle **101** of FIG. **1** including, but is not limited to, perception and planning system **110**, control system **111**, and sensor system **115**. Referring to FIG. **3**, perception and planning system **110** includes, but is not limited to, localization module **301**, perception module **302**, decision module **303**, planning module **304**, control module **305**, driving behavior learning module **306**, and driving style determination module **307**.

Some or all of modules **301-307** may be implemented in software, hardware, or a combination thereof. For example, these modules may be installed in persistent storage device **352**, loaded into memory **351**, and executed by one or more processors (not shown). Note that some or all of these modules may be communicatively coupled to or integrated with some or all modules of vehicle control system **111** of FIG. **2**. Some of modules **301-307** may be integrated together as an integrated module.

Localization module **301** (also referred to as a map and route module) manages any data related to a trip or route of a user. A user may log in and specify a starting location and a destination of a trip, for example, via a user interface. Localization module **301** communicates with other components of autonomous vehicle **300**, such as map and route information **311**, to obtain the trip related data. For example, localization module **301** may obtain location and route information from a location server and a map and POI (MPOI) server. A location server provides location services and an MPOI server provides map services and the POIs of certain locations, which may be cached as part of map and route information **311**. During traveling of autonomous vehicle **300** along the route, localization module **301** may also obtain real-time traffic information from a traffic information system or server.

Based on the sensor data provided by sensor system **115** and localization information obtained by localization module **301**, a perception of the surrounding environment is determined by perception module **302**. The perception information may represent what an ordinary driver would perceive surrounding a vehicle in which the driver is driving. The perception can include the lane configuration (e.g., straight or curve lanes), traffic light signals, a relative position of another vehicle, a pedestrian, a building, crosswalk, or other traffic related signs (e.g., stop signs, yield signs), etc., for example, in a form of an object.

Perception module **302** may include a computer vision system or functionalities of a computer vision system to process and analyze images captured by one or more cameras in order to identify objects and/or features in the environment of autonomous vehicle. The objects can include traffic signals, road way boundaries, other vehicles, pedestrians, and/or obstacles, etc. The computer vision system may use an object recognition algorithm, video tracking, and other computer vision techniques. In some embodiments, the computer vision system can map an environment, track objects, and estimate the speed of objects, etc. Perception module **302** can also detect objects based on other sensors data provided by other sensors such as a radar and/or LIDAR.

For each of the objects, decision module **303** makes a decision regarding how to handle the object. For example, for a particular object (e.g., another vehicle in a crossing route) as well as its metadata describing the object (e.g., a speed, direction, turning angle), decision module **303** decides how to encounter the object (e.g., overtake, yield, stop, pass). Decision module **303** may make such decisions according to a set of rules such as traffic rules, which may be stored in persistent storage device **352** (not shown).

Based on a decision for each of the objects perceived, planning module **304** plans a path or route for the autonomous vehicle, as well as driving parameters (e.g., distance, speed, and/or turning angle). That is, for a given object, decision module **303** decides what to do with the object, while planning module **304** determines how to do it. For example, for a given object, decision module **303** may decide to pass the object, while planning module **304** may determine whether to pass on the left side or right side of the object. Planning and control data is generated by planning module **304** including information describing how vehicle **300** would move in a next moving cycle (e.g., next route/path segment). For example, the planning and control data may instruct vehicle **300** to move 10 meters at a speed of 30 mile per hour (mph), then change to a right lane at the speed of 25 mph.

Based on the planning and control data, control module **305** controls and drives the autonomous vehicle, by sending proper commands or signals to vehicle control system **111**, according to a route or path defined by the planning and control data. The planning and control data include sufficient information to drive the vehicle from a first point to a second point of a route or path using appropriate vehicle settings or driving parameters (e.g., throttle, braking, and turning commands) at different points in time along the path or route.

Note that decision module **303** and planning module **304** may be integrated as an integrated module. Decision module **303**/planning module **304** may include a navigation system or functionalities of a navigation system to determine a driving path for the autonomous vehicle. For example, the navigation system may determine a series of speeds and directional headings to effect movement of the autonomous vehicle along a path that substantially avoids perceived obstacles while generally advancing the autonomous vehicle along a roadway-based path leading to an ultimate destination. The destination may be set according to user inputs via user interface system **113**. The navigation system may update the driving path dynamically while the autonomous vehicle is in operation. The navigation system can incorporate data from a GPS system and one or more maps so as to determine the driving path for the autonomous vehicle.

Decision module **303**/planning module **304** may further include a collision avoidance system or functionalities of a collision avoidance system to identify, evaluate, and avoid or otherwise negotiate potential obstacles in the environment of the autonomous vehicle. For example, the collision avoidance system may effect changes in the navigation of the autonomous vehicle by operating one or more subsystems in control system **111** to undertake swerving maneuvers, turning maneuvers, braking maneuvers, etc. The collision avoidance system may automatically determine feasible obstacle avoidance maneuvers on the basis of surrounding traffic patterns, road conditions, etc. The collision avoidance system may be configured such that a swerving maneuver is not undertaken when other sensor systems detect vehicles, construction barriers, etc. in the region adjacent the autonomous vehicle that would be swerved into. The collision avoidance system may automatically select the maneuver that is both available and maximizes safety of occupants of the autonomous vehicle. The collision avoidance system may select an avoidance maneuver predicted to cause the least amount of acceleration in a passenger cabin of the autonomous vehicle.

In one embodiment, referring back to FIG. **3**, in making a decision, decision module **303** invokes driving behavior learning module **306** to learn and observe the driving behaviors of surrounding vehicles. The driving behavior of a vehicle refers to an average speed, acceleration rate, deceleration rate, how close the vehicle follows another vehicle ahead, how often it changes lanes, how fast it changes lanes, how sharp a turning angle is when changing lanes, etc. Based on the driving behaviors learned by driving behavior learning module **306**, driving style determination module **307** determines a list of one or more driving style elements for each of the surrounding vehicles that may affect changing lanes of autonomous vehicle **300**.

A vehicle that may affect changing lanes of vehicle **300** may be a vehicle moving within a current lane from which vehicle **300** attempts to change (e.g., an ahead vehicle, a tailgating vehicle), a vehicle moving into a target lane to which vehicle **300** attempt to change, or any other vehicles that are within a predetermined proximity (e.g., a corresponding driving area) with respect to vehicle **300**. A driving style element may refer to a driving speed of a vehicle, a distance between two vehicles, a deceleration rate of a vehicle, or a distance for deceleration (from deceleration to complete stop). A driving style element may further refer to a frequency of changing lanes, a speed of changing lanes, or a turning angle of changing lanes. The information regarding the driving behaviors and/or driving style elements may be stored in persistent storage device **352** as a part of driving style information **312**.

Once the driving style elements have been extracted from the perceived driving behaviors, driving style determination module **307** transmits the driving style elements to a remote server over a network. The remote server may be a part of server **103** of FIG. **1**. The remote server collects the driving style elements from a number of vehicles that are located within the same driving area with respect to vehicle **300**. The remote server determines a driving style for the driving area based on the driving style elements received from various vehicles moving within the driving areas. In one embodiment, the remote server may calculate an averaged value from each type of driving style elements received from various vehicles. In one embodiment, information of a driving style may refer to an average speed, an average frequency of changing lanes, an average distance between two vehicles moving in the same lane, an average acceleration rate, an average deceleration rate, and/or an average angle of changing lanes of vehicles that are located within the targeted driving area.

Once the driving style has been determined, the remote server transmits over the network the information concerning the driving style to the vehicles that are located within the corresponding driving area. Note that a vehicle may be located in different driving areas between the time of transmitting driving style elements to the remote server and the time of receiving a driving style from the remote server. For example, as shown in FIG. **5**, when autonomous vehicle **300** transmits driving style elements to the remote server, vehicle **300** may be in driving area **501** at the time. Thus, the driving style elements represent the driving behaviors of the vehicles located within the first driving area at the time. However, when the remote server determines the driving style for the first driving area and is ready to transmit the driving style of the first driving area, autonomous vehicle **300** may be in driving area **502** or driving area **503** as vehicle **300** is moving. Thus, autonomous vehicle **300** may not receive the driving style for driving area **501**. Rather, autonomous vehicle **300** may receive a second driving style for driving area **502** or driving area **503**. The second driving style for second driving area **502** or driving area **503** may be determined based on the driving style elements submitted by other autonomous vehicles.

Assuming vehicle **300** is still located within the same driving area, driving style determination module **307** receives the driving style from the remote server. In response to the driving style provided by driving style determination module **307**, decision module **303** makes a decision of adopting the driving style and planning module **304** generates planning and control data based on the decision or decisions of decision module **303**. Based on the planning and control data, control module **305** controls and drives autonomous vehicle **300** accordingly.

FIG. **6** is a flow diagram illustrating a process of operating an autonomous vehicle according one embodiment of the invention. Process **600** may be performed by processing logic which may include software, hardware, or a combination thereof. For example, process **600** may be performed by perception and planning system **110** of FIG. **3**. Referring to FIG. **6**, at block **601**, processing logic monitors and perceives driving behaviors of one or more vehicles surrounding an autonomous vehicle. The surrounding vehicles are within a predetermined proximity or driving area with respect to the autonomous vehicle. At block **602**, for each of the surrounding vehicles, processing logic determines a list of one or more driving style elements based on the perceived driving behaviors. At block **603**, the driving style elements are transmitted to a remote server over a network to allow the remote server to determine a driving style corresponding to the driving area. At block **604**, a response is received from the remote server. The response includes a driving style determined by the remote server based on the driving style elements collected from various vehicles. At block **605**, planning and control data is generated for a next driving cycle (e.g., next route segment) based in part on the driving style to adopt the driving style of the driving area. At block **606**, the autonomous vehicle is controlled and driven based on the planning and control data.

FIG. **7** is a flow diagram illustrating a process of determining driving styles for operating autonomous vehicles according one embodiment of the invention. Process **700** may be performed by processing logic which may include software, hardware, or a combination thereof. For example, process **700** may be performed by data analytics system or

server **103** of FIG. **3**. Referring to FIG. **7**, at block **701**, processing logic receives driving style elements from a number of autonomous vehicles over a network. At block **702**, processing logic determines one or more driving areas based on the locations of the autonomous vehicles. At block **703**, for each of the driving areas, processing logic identifies one or more vehicles that are located within the driving area. At block **704**, processing logic analyzes the driving style elements associated with the vehicles within the driving area. At block **705**, processing logic determines a driving style for the driving area based on the analysis. At block **706**, processing logic transmits the driving style to each of the autonomous vehicles located in the driving area at the point in time. Processing logic optionally stores the driving styles for various driving areas in a database for future usage. The historic driving styles of a driving area may be utilized to determine future driving styles for the same or similar driving area.

The techniques described above require an autonomous vehicle transmitting the driving style elements to a centralized server over a network such as a cloud network. In some situations, such a network connection may be unavailable. For example, if a vehicle is travelling in a city, certain wireless signals (e.g., cellular signals) may be blocked by the tall buildings. Similarly, when a vehicle is travelling in a suburban area, there may not be a cellular tower or basestation available either. As a result, the centralized server may not be utilized appropriately.

According to one embodiment, when an autonomous vehicle detects that a network connection with a remote server is unavailable, the autonomous vehicle may communicate with other vehicles nearby over a wireless local area network to exchange the driving style elements. The autonomous vehicle then determines the driving style based on the exchanged driving style elements and adopts the driving style accordingly. That is, instead of centrally determining a driving style for a driving area at a remote server, each autonomous vehicle can determine the driving style based on the driving style elements exchanged with other nearby autonomous vehicles.

Referring now to FIG. **8**, in this example, a network connection to remote server **103** is unavailable. Each of autonomous vehicles **101**A-**101**D maintains a local network connection each the rest of the autonomous vehicles within a particular driving area represented by FIG. **8**. When deciding a next moving cycle, each of autonomous vehicles **101**A-**101**D perceives driving behaviors of the surrounding vehicles and determines driving style elements based on the driving behaviors. Each of autonomous vehicles **101**A-**101**D then exchanges the driving style elements with the rest of the autonomous vehicles in the driving area. Based on the exchanged driving style elements, at least one of autonomous vehicles **101**A-**101**D determines the driving style and adopts the driving style in deciding the next moving cycle.

For example, when autonomous vehicle **101**A detects that a network connection with sever **103** is unavailable, autonomous vehicle **101**A communicates with other autonomous vehicles in the driving area such as autonomous vehicles **101**B-**101**D to establish a WLAN connection. Autonomous vehicle **101**A then transmits a first set of driving style elements concerning driving behaviors of its surrounding vehicles to autonomous vehicles **101**B-**101**D to exchange a second set, a third set, and a fourth set of driving style elements of vehicles surrounding autonomous vehicles **101**B-**101**D, respectively. Autonomous vehicle **101**A then aggregates at least some of the first set, second set, third set, and fourth set of driving style elements to determine a driving style. Autonomous vehicle **101**A then adopts the driving style in deciding a next moving cycle.

FIG. **9** is a flow diagram illustrating a process of operating an autonomous vehicle according one embodiment of the invention. Process **900** may be performed by processing logic which may include software, hardware, or a combination thereof. For example, process **900** may be performed by perception and planning system **110** of FIG. **3**. Referring to FIG. **9**, at block **901**, processing logic monitors and perceives driving behaviors of vehicles surrounding an autonomous vehicle. At block **902**, for each of the surrounding vehicles, processing logic determines a list of driving style elements based on the perceived driving behaviors. At block **903**, processing logic transmits the driving style elements to one or more other autonomous vehicles in the driving area to exchange the driving style elements generated by those autonomous vehicles. At block **904**, processing logic aggregates the driving style elements that were generated by itself and received from other autonomous vehicles in the driving area. A driving style is then determined based on the aggregated driving style elements. At block **905**, processing logic generates planning and control data based in part on the driving style. At block **906**, the autonomous vehicle is controlled and driven based on the planning and control data.

Note that some or all of the components as shown and described above may be implemented in software, hardware, or a combination thereof. For example, such components can be implemented as software installed and stored in a persistent storage device, which can be loaded and executed in a memory by a processor (not shown) to carry out the processes or operations described throughout this application. Alternatively, such components can be implemented as executable code programmed or embedded into dedicated hardware such as an integrated circuit (e.g., an application specific IC or ASIC), a digital signal processor (DSP), or a field programmable gate array (FPGA), which can be accessed via a corresponding driver and/or operating system from an application. Furthermore, such components can be implemented as specific hardware logic in a processor or processor core as part of an instruction set accessible by a software component via one or more specific instructions.

FIG. **10** is a block diagram illustrating an example of a data processing system which may be used with one embodiment of the invention. For example, system **1500** may represent any of data processing systems described above performing any of the processes or methods described above, such as, for example, perception and planning system **110** or any of servers **103**-**104** of FIG. **1**. System **1500** can include many different components. These components can be implemented as integrated circuits (ICs), portions thereof, discrete electronic devices, or other modules adapted to a circuit board such as a motherboard or add-in card of the computer system, or as components otherwise incorporated within a chassis of the computer system.

Note also that system **1500** is intended to show a high level view of many components of the computer system. However, it is to be understood that additional components may be present in certain implementations and furthermore, different arrangement of the components shown may occur in other implementations. System **1500** may represent a desktop, a laptop, a tablet, a server, a mobile phone, a media player, a personal digital assistant (PDA), a Smartwatch, a personal communicator, a gaming device, a network router or hub, a wireless access point (AP) or repeater, a set-top box, or a combination thereof. Further, while only a single machine or system is illustrated, the term "machine" or

"system" shall also be taken to include any collection of machines or systems that individually or jointly execute a set (or multiple sets) of instructions to perform any one or more of the methodologies discussed herein.

In one embodiment, system **1500** includes processor **1501**, memory **1503**, and devices **1505-1508** via a bus or an interconnect **1510**. Processor **1501** may represent a single processor or multiple processors with a single processor core or multiple processor cores included therein. Processor **1501** may represent one or more general-purpose processors such as a microprocessor, a central processing unit (CPU), or the like. More particularly, processor **1501** may be a complex instruction set computing (CISC) microprocessor, reduced instruction set computing (RISC) microprocessor, very long instruction word (VLIW) microprocessor, or processor implementing other instruction sets, or processors implementing a combination of instruction sets. Processor **1501** may also be one or more special-purpose processors such as an application specific integrated circuit (ASIC), a cellular or baseband processor, a field programmable gate array (FPGA), a digital signal processor (DSP), a network processor, a graphics processor, a network processor, a communications processor, a cryptographic processor, a co-processor, an embedded processor, or any other type of logic capable of processing instructions.

Processor **1501**, which may be a low power multi-core processor socket such as an ultra-low voltage processor, may act as a main processing unit and central hub for communication with the various components of the system. Such processor can be implemented as a system on chip (SoC). Processor **1501** is configured to execute instructions for performing the operations and steps discussed herein. System **1500** may further include a graphics interface that communicates with optional graphics subsystem **1504**, which may include a display controller, a graphics processor, and/or a display device.

Processor **1501** may communicate with memory **1503**, which in one embodiment can be implemented via multiple memory devices to provide for a given amount of system memory. Memory **1503** may include one or more volatile storage (or memory) devices such as random access memory (RAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), static RAM (SRAM), or other types of storage devices. Memory **1503** may store information including sequences of instructions that are executed by processor **1501**, or any other device. For example, executable code and/or data of a variety of operating systems, device drivers, firmware (e.g., input output basic system or BIOS), and/or applications can be loaded in memory **1503** and executed by processor **1501**. An operating system can be any kind of operating systems, such as, for example, Robot Operating System (ROS), Windows® operating system from Microsoft®, Mac OS®/iOS® from Apple, Android® from Google®, LINUX, UNIX, or other real-time or embedded operating systems.

System **1500** may further include IO devices such as devices **1505-1508**, including network interface device(s) **1505**, optional input device(s) **1506**, and other optional IO device(s) **1507**. Network interface device **1505** may include a wireless transceiver and/or a network interface card (NIC). The wireless transceiver may be a WiFi transceiver, an infrared transceiver, a Bluetooth transceiver, a WiMax transceiver, a wireless cellular telephony transceiver, a satellite transceiver (e.g., a global positioning system (GPS) transceiver), or other radio frequency (RF) transceivers, or a combination thereof. The NIC may be an Ethernet card.

Input device(s) **1506** may include a mouse, a touch pad, a touch sensitive screen (which may be integrated with display device **1504**), a pointer device such as a stylus, and/or a keyboard (e.g., physical keyboard or a virtual keyboard displayed as part of a touch sensitive screen). For example, input device **1506** may include a touch screen controller coupled to a touch screen. The touch screen and touch screen controller can, for example, detect contact and movement or break thereof using any of a plurality of touch sensitivity technologies, including but not limited to capacitive, resistive, infrared, and surface acoustic wave technologies, as well as other proximity sensor arrays or other elements for determining one or more points of contact with the touch screen.

IO devices **1507** may include an audio device. An audio device may include a speaker and/or a microphone to facilitate voice-enabled functions, such as voice recognition, voice replication, digital recording, and/or telephony functions. Other IO devices **1507** may further include universal serial bus (USB) port(s), parallel port(s), serial port(s), a printer, a network interface, a bus bridge (e.g., a PCI-PCI bridge), sensor(s) (e.g., a motion sensor such as an accelerometer, gyroscope, a magnetometer, a light sensor, compass, a proximity sensor, etc.), or a combination thereof. Devices **1507** may further include an imaging processing subsystem (e.g., a camera), which may include an optical sensor, such as a charged coupled device (CCD) or a complementary metal-oxide semiconductor (CMOS) optical sensor, utilized to facilitate camera functions, such as recording photographs and video clips. Certain sensors may be coupled to interconnect **1510** via a sensor hub (not shown), while other devices such as a keyboard or thermal sensor may be controlled by an embedded controller (not shown), dependent upon the specific configuration or design of system **1500**.

To provide for persistent storage of information such as data, applications, one or more operating systems and so forth, a mass storage (not shown) may also couple to processor **1501**. In various embodiments, to enable a thinner and lighter system design as well as to improve system responsiveness, this mass storage may be implemented via a solid state device (SSD). However in other embodiments, the mass storage may primarily be implemented using a hard disk drive (HDD) with a smaller amount of SSD storage to act as a SSD cache to enable non-volatile storage of context state and other such information during power down events so that a fast power up can occur on re-initiation of system activities. Also a flash device may be coupled to processor **1501**, e.g., via a serial peripheral interface (SPI). This flash device may provide for non-volatile storage of system software, including BIOS as well as other firmware of the system.

Storage device **1508** may include computer-accessible storage medium **1509** (also known as a machine-readable storage medium or a computer-readable medium) on which is stored one or more sets of instructions or software (e.g., module, unit, and/or logic **1528**) embodying any one or more of the methodologies or functions described herein. Processing module/unit/logic **1528** may represent any of the components described above, such as, for example, driving style analysis module **122**, driving style determination **307**, or driving behavior learning module **306**. Processing module/unit/logic **1528** may also reside, completely or at least partially, within memory **1503** and/or within processor **1501** during execution thereof by data processing system **1500**, memory **1503** and processor **1501** also constituting machine-accessible storage media. Processing module/unit/

logic **1528** may further be transmitted or received over a network via network interface device **1505**.

Computer-readable storage medium **1509** may also be used to store the some software functionalities described above persistently. While computer-readable storage medium **1509** is shown in an exemplary embodiment to be a single medium, the term "computer-readable storage medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The terms "computer-readable storage medium" shall also be taken to include any medium that is capable of storing or encoding a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the present invention. The term "computer-readable storage medium" shall accordingly be taken to include, but not be limited to, solid-state memories, and optical and magnetic media, or any other non-transitory machine-readable medium.

Processing module/unit/logic **1528**, components and other features described herein can be implemented as discrete hardware components or integrated in the functionality of hardware components such as ASICS, FPGAs, DSPs or similar devices. In addition, processing module/unit/logic **1528** can be implemented as firmware or functional circuitry within hardware devices. Further, processing module/unit/logic **1528** can be implemented in any combination hardware devices and software components.

Note that while system **1500** is illustrated with various components of a data processing system, it is not intended to represent any particular architecture or manner of interconnecting the components; as such details are not germane to embodiments of the present invention. It will also be appreciated that network computers, handheld computers, mobile phones, servers, and/or other data processing systems which have fewer components or perhaps more components may also be used with embodiments of the invention.

Some portions of the preceding detailed descriptions have been presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the ways used by those skilled in the perception and planning arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of operations leading to a desired result. The operations are those requiring physical manipulations of physical quantities.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the above discussion, it is appreciated that throughout the description, discussions utilizing terms such as those set forth in the claims below, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

Embodiments of the invention also relate to an apparatus for performing the operations herein. Such a computer program is stored in a non-transitory computer readable medium. A machine-readable medium includes any mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a machine-readable (e.g., computer-readable) medium includes a machine (e.g., a computer) readable storage medium (e.g., read only memory ("ROM"), random access memory ("RAM"), magnetic disk storage media, optical storage media, flash memory devices).

The processes or methods depicted in the preceding figures may be performed by processing logic that comprises hardware (e.g. circuitry, dedicated logic, etc.), software (e.g., embodied on a non-transitory computer readable medium), or a combination of both. Although the processes or methods are described above in terms of some sequential operations, it should be appreciated that some of the operations described may be performed in a different order. Moreover, some operations may be performed in parallel rather than sequentially.

Embodiments of the present invention are not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of embodiments of the invention as described herein.

In the foregoing specification, embodiments of the invention have been described with reference to specific exemplary embodiments thereof. It will be evident that various modifications may be made thereto without departing from the broader spirit and scope of the invention as set forth in the following claims. The specification and drawings are, accordingly, to be regarded in an illustrative sense rather than a restrictive sense.

What is claimed is:

1. A non-transitory machine-readable medium storing instructions, which when executed by a processor, cause the processor to perform operations of operating an autonomous vehicle, the operations comprising:

perceiving, by a first autonomous vehicle, driving behaviors of one or more first surrounding vehicles, each of the one or more first surrounding vehicles surrounding the first autonomous vehicle;

determining, for each of the one or more first surrounding vehicles, first information describing one or more driving style elements based on a driving behavior of the surrounding vehicle;

transmitting second information describing a first set of driving style elements representing driving behaviors of the one or more first surrounding vehicles from the first autonomous vehicle to a second autonomous vehicle over a wireless network, the second information comprising some or all of the first information;

receiving third information describing a second set of driving style elements from the second autonomous vehicle, the second set of driving style elements determined by the second autonomous vehicle based on a perception of driving behaviors of one or more second surrounding vehicles surrounding the second autonomous vehicle;

determining a driving style based on at least some of the second information and at least some of the third information, wherein the driving style includes fourth information describing how the first autonomous vehicle should drive at a point in time in view of the one or more first surrounding vehicles, the one or more second surrounding vehicles, or both; and

operating the first autonomous vehicle based on planning and control data generated based, at least in part, on the driving style, wherein operating the first autonomous

vehicle comprises controlling the first autonomous vehicle, driving the first autonomous vehicle, or both.

2. The non-transitory machine-readable medium of claim 1, wherein the first autonomous vehicle and the second autonomous vehicle are located within a predetermined proximity at the point in time.

3. The non-transitory machine-readable medium of claim 1, wherein the operations further comprise transmitting a location of each of the one or more first surrounding vehicles surrounding the first autonomous vehicle to the second autonomous vehicle, wherein the second set of driving style elements is determined based on locations of the one or more first surrounding vehicles.

4. The non-transitory machine-readable medium of claim 1, wherein the operations further comprise receiving a location of each of the one or more second surrounding vehicles surrounding the second autonomous vehicle, wherein determining the driving style is further based on locations of the one or more second surrounding vehicles surrounding the second autonomous vehicle.

5. The non-transitory machine-readable medium of claim 1, wherein the first set of driving style elements, the second set of driving style elements, or both comprises at least one selected from a group consisting of:

a driving speed associated with the one or more first surrounding vehicles or the one or more second surrounding vehicles,

a distance between a plurality of the one or more first surrounding vehicles,

a distance between a plurality of the one or more second surrounding vehicles,

a distance between one of the one or more first surrounding vehicles and one of the one or more second surrounding vehicles,

a deceleration rate associated with the one or more first surrounding vehicles or the one or more second surrounding vehicles, and

a distance of deceleration associated with the one or more first surrounding vehicles or the one or more second surrounding vehicles.

6. The non-transitory machine-readable medium of claim 5, wherein the first set of driving style elements, the second set of driving style elements, or both further comprises at least one selected from a group consisting of:

a frequency of lane changes,

a speed of a lane change, and

a turning angle of a lane change.

7. A computer-implemented method for operating autonomous driving vehicles, the method comprising:

receiving, at a server, first information describing one or more driving style elements associated with a plurality of autonomous driving vehicles (ADVs) over a network;

determining one or more driving areas based on locations of the plurality of ADVs; and

for each of the one or more driving areas,

identifying a first set of ADVs that are within a predetermined proximity of the driving area, the first set of ADVs comprising one or more ADVs from the plurality of ADVs,

performing an analysis on second information describing one or more driving style elements that are associated with the first set of ADVs, the first information comprising the second information,

determining a driving style corresponding to the driving area based on the analysis, and

transmitting the driving style to a second set of ADVs that are within the predetermined proximity of the driving area, the second set of ADVs comprising one or more ADVs from the plurality of ADVs and the driving style including third information describing how each ADV from the second set of ADVs should drive in the driving area.

8. The method of claim 7, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a current speed of ADV in the first set based on some or all of the second information; and

calculating an average speed for all ADVs in the first set based on current speeds of all ADVs in the first set.

9. The method of claim 7, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a distance between each pair of adjacent ADVs in the first set based on some or all of the second information; and

calculating an average distance of the for all pairs of adjacent ADVs in the first set based on [[the]]distances between all pairs of adjacent ADVs in the first set.

10. The method of claim 7, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a deceleration rate of each ADV in the first set based on some or all of the second information; and

calculating an average deceleration rate for all ADVs in the first set based on deceleration rates of all ADVs in the first set.

11. The method of claim 10, further comprising:

determining a deceleration distance of each ADV in the first set based on the deceleration rate ADV; and

calculating an average deceleration distance for all ADVs in the first set based on deceleration distances of all ADVs in the first set.

12. The method of claim 7, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a number of lane changes of each of the ADV in the first set based on some or all of the second information; and

calculating an average number of lane changes for all ADVs in the first set based on numbers of lane changes of all ADVs in the first set.

13. The method of claim 12, further comprising determining an average speed of lane changes for all ADVs in the first set based on some or all of the second information.

14. The method of claim 12, further comprising determining an average turning angle of lane changes for all ADVs in the first set based on some or all of the second information.

15. A non-transitory machine-readable medium having instructions stored therein, which when executed by a processor, cause the processor to perform operations of operating autonomous driving vehicles, the operations comprising:

receiving, at a server, first information describing one or more driving style elements from a plurality of autonomous driving vehicles (ADVs) over a network;

determining one or more driving areas based on locations of the plurality of ADVs; and

for each of the one or more driving areas,

identifying a first set of ADVs that are within a predetermined proximity of the driving area, the first set of ADVs comprising one or more ADVs from the plurality of ADVs,

performing an analysis on second information describing one or more driving style elements that are associated with the first set of ADVs, the first information comprising the second information,

determining a driving style corresponding to the driving area based on the analysis, and

transmitting the driving style to a second set of ADVs that are within the predetermined proximity of the driving area, the second set of ADVs comprising one or more ADVs from the plurality of ADVs and the driving style including third information describing how each ADV from the second set of ADVs should drive in the driving area.

16. The non-transitory machine-readable medium of claim **15**, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a current speed of each ADV in the first set based on some or all of the second information; and

calculating an average speed for all ADVs in the first set based on current speeds of all ADVs in the first set.

17. The non-transitory machine-readable medium of claim **15**, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a distance between each pair of adjacent ADVs in the first set based on some or all of the second information; and

calculating an average distance of the for all pairs of adjacent ADVs in the first set based on distances between each adjacent all pairs of adjacent ADVs in the first set.

18. The non-transitory machine-readable medium of claim **15**, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a deceleration rate of each ADV in the first set based on some or all of the second information; and

calculating an average deceleration rate for all ADVs in the first set based on deceleration rates of all ADVs in the first set.

19. The non-transitory machine-readable medium of claim **18**, wherein the operations further comprise:

determining a deceleration distance of each ADV in the first set the deceleration rate of the ADV; and

calculating an average deceleration distance for all ADVs in the first set based on deceleration distances of all ADVs in the first set.

20. The non-transitory machine-readable medium of claim **15**, wherein determining a driving style corresponding to the driving area based on the analysis comprises:

determining a number of lane changes of each ADV in the first set based on some or all of the second information; and

calculating an average number of lane changes for all ADVs in the first set based on numbers of lane changes of all ADVs in the first set.

21. The non-transitory machine-readable medium of claim **20**, wherein the operations further comprise determining an average speed of a lane change for all ADVs in the first set based on some or all of the second information.

22. The non-transitory machine-readable medium of claim **20**, wherein the operations further comprise determining an average turning angle of a lane change for all ADVs in the first set based on some or all of the second information.

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